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Interconnectivity of Iron-sulfide Melts in an Olivine Matrix

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The separation of molten metal from silicates during and after the accretion of terrestrial planets may have involved a percolation of molten iron-sulfide through solid silicates. In this study we performed experiments on aggregates of natural S. Carlos olivine powder with some amounts of synthetic Fe and S powders to determine the percolation threshold for this simplified model. The powder mixtures of olivine and Fe70S30 (wt%) were annealed at 1 GPa and 900 °C in a conventional piston-cylinder press for a week. The electrical conductivity of the samples was measured using the impedance spectroscopy method in BN-graphite-CaF2 pressure cells with concentric cylindrical electrodes made from Mo or Re foils.The conductivity was initially very high for samples containing up to 15% vol. of iron-sulfide and decreased dramatically after the temperature was risen above the melting point of the Fe-S alloy (980 °C). Only for samples with 20% vol. of Fe-S the conductivity remained high for the entire duration of the run. By measuring the conductivity of the sample during the cooling cycle of the experiment, it is possible to compute the activation energy of the material. The values of the activation energies were similar to that of pure olivine (i.e. ca. 1.50 eV) for samples with a maximum Fe-S content of 15% vol., whereas the activation energy of the material with 20% vol. of iron-sulfide is only 0.06 eV (typical for metal alloys). These results show that an interconnectivity threshold for olivine plus iron-sulfide aggregates is larger than 15% vol. of Fe-S melt, in disagreement with what is reported in Yoshino et al. (2005). Moreover, it is evident that the presence of iron-sulfide melt pockets between olivine grains does not play a significant role in modifying the activation energy of the aggregate, unless the melt forms an interconnected network.